Transmutation Reactions Induced by D2 Gas Permeation through Pd Complexes (Pd/CaO/Pd)

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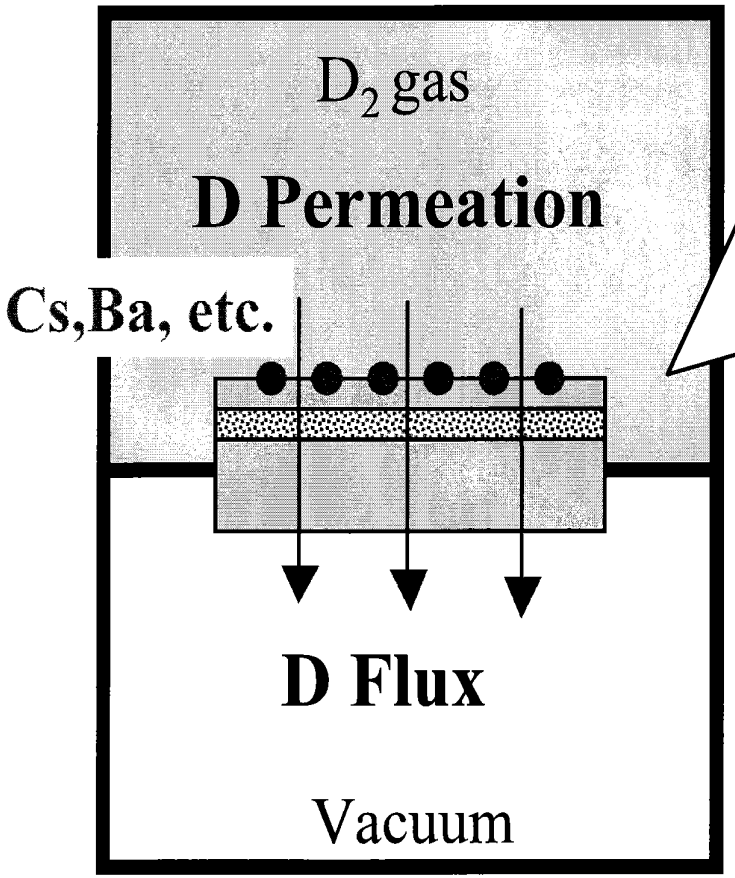
3-3 Effect of gradient T for deuterium density

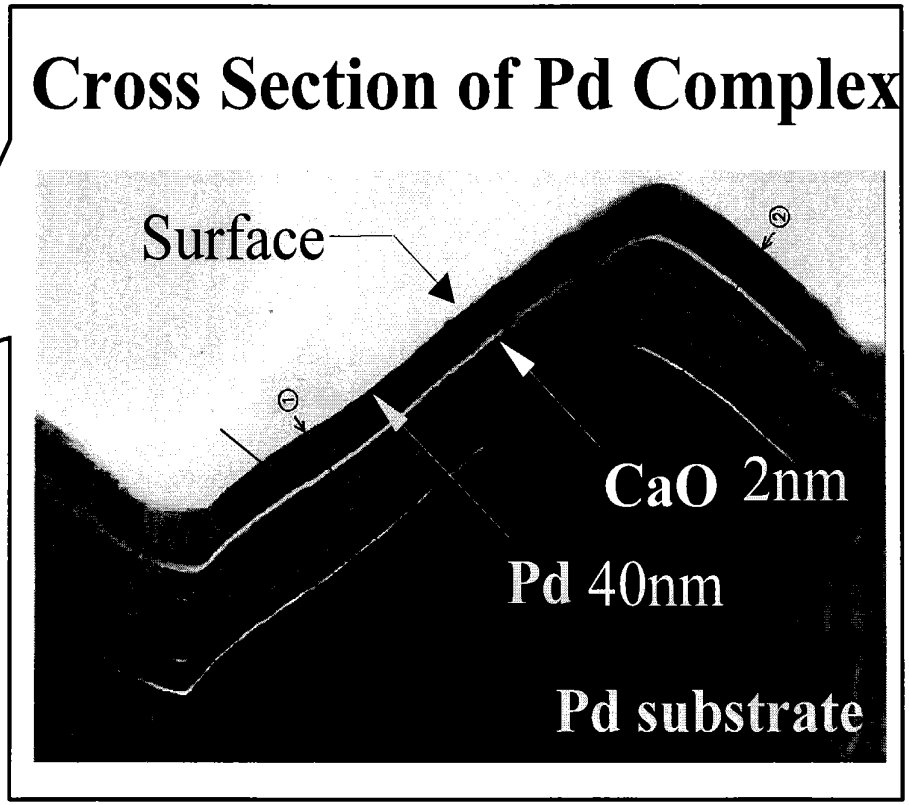
4. Concluding Remarks

Features of the Present Method

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D_2 gas permeation through the Pd complex





Fabrication of Pd Complex

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Washing a Palladium Sample with Acetone

↓

900° C 10H Annealing under Vacuum Condition (< 10^{-7} Torr)

↓

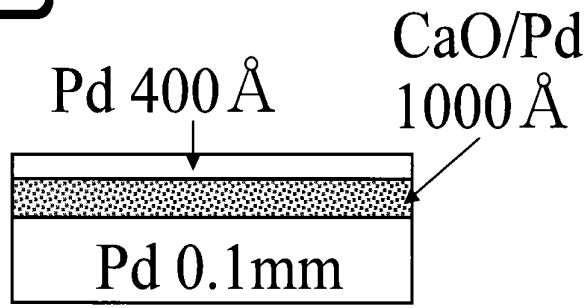
Washing the Sample with Aqua Regia (100sec)

↓

5 times Alternatingly Sputtering of CaO(20 Å) and Pd(180 Å)

↓

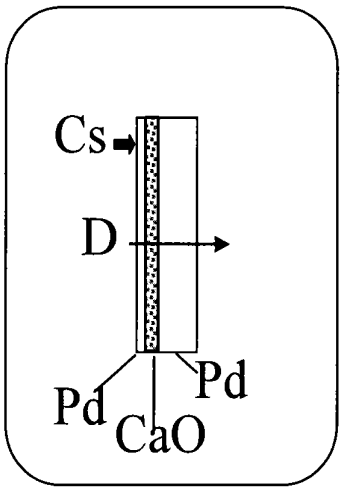
Ion Beam Sputtering of Pd only (400 Å)

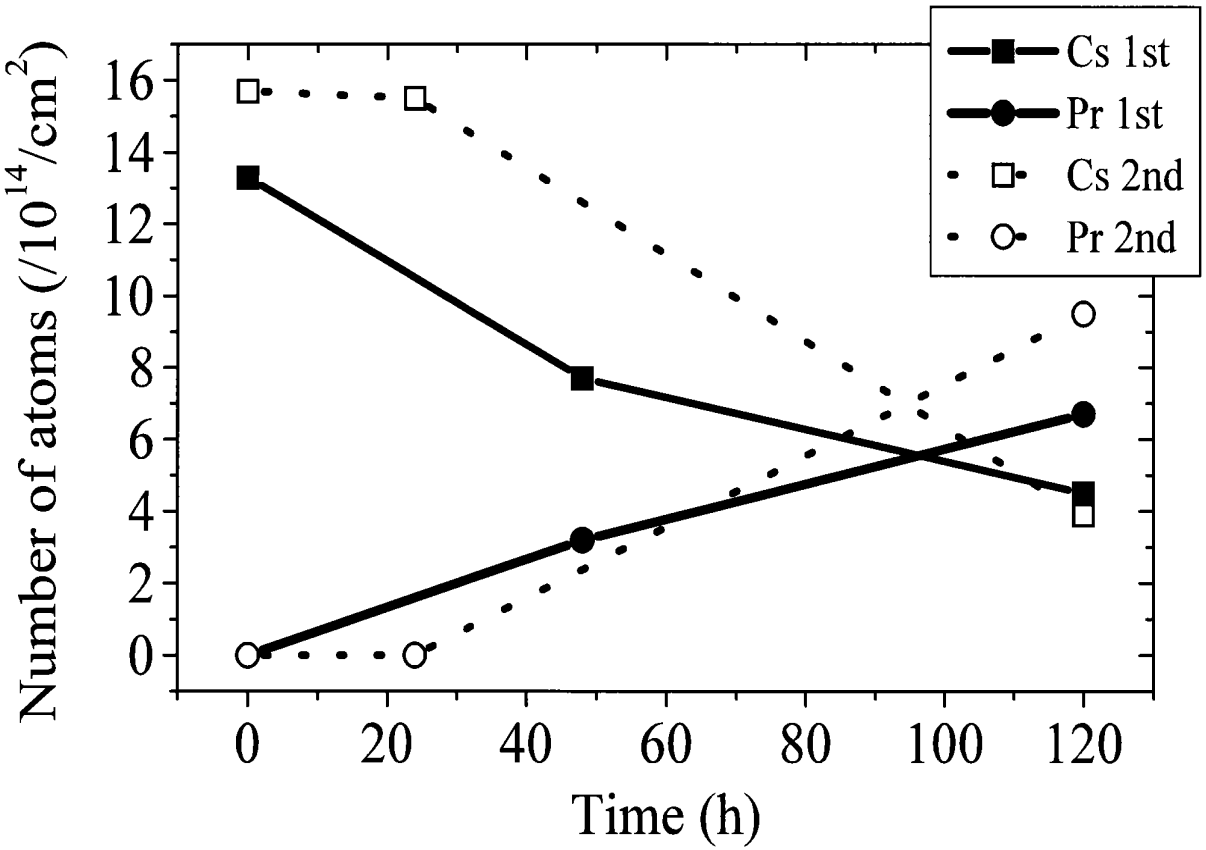


25mm × 25mm

Decrease of Cs and Emergence of Pr

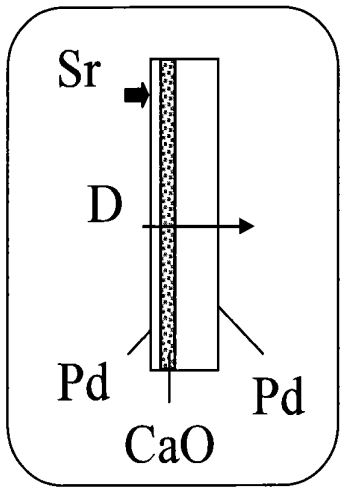
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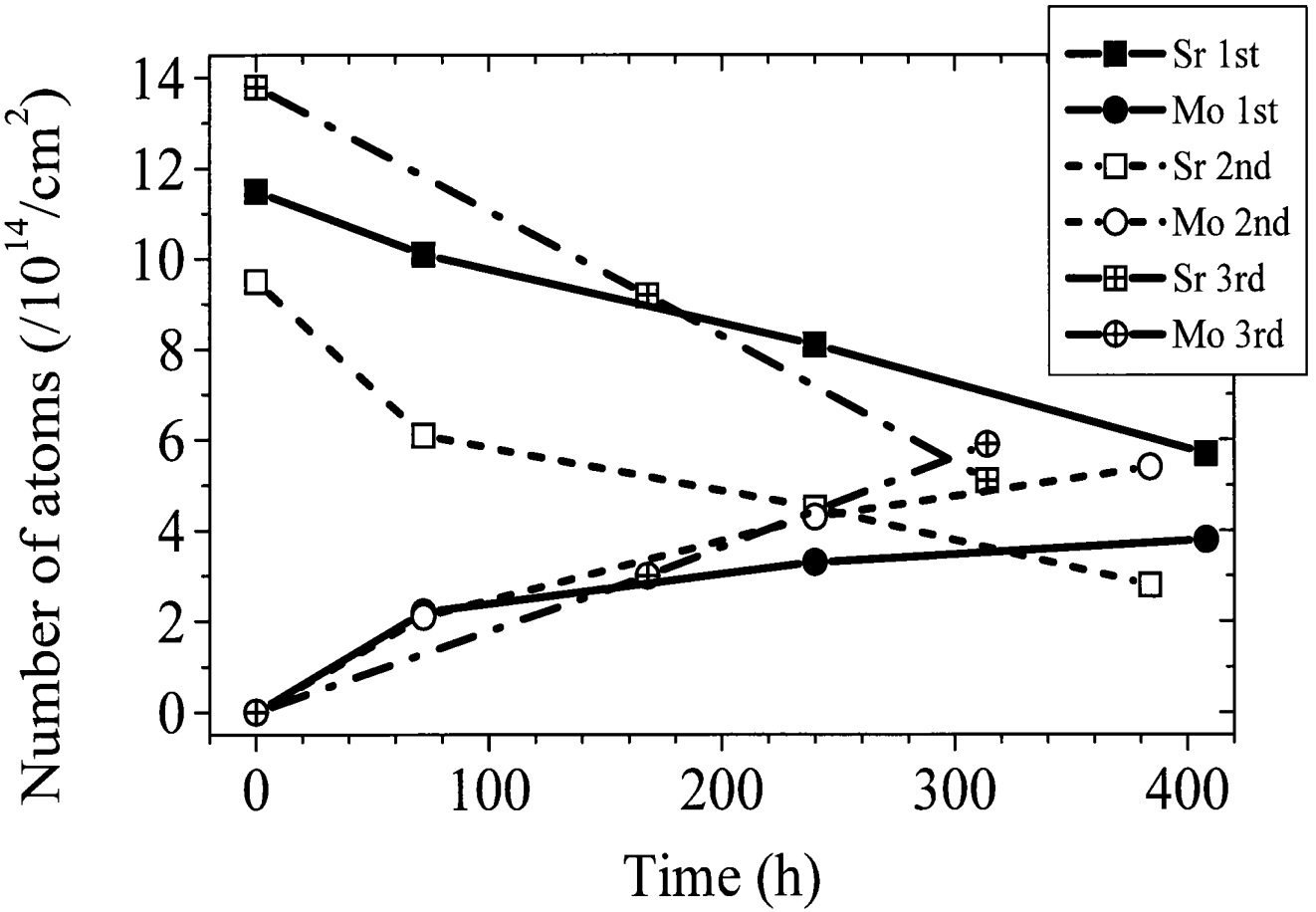




Decrease of Sr and Emergence of Mo

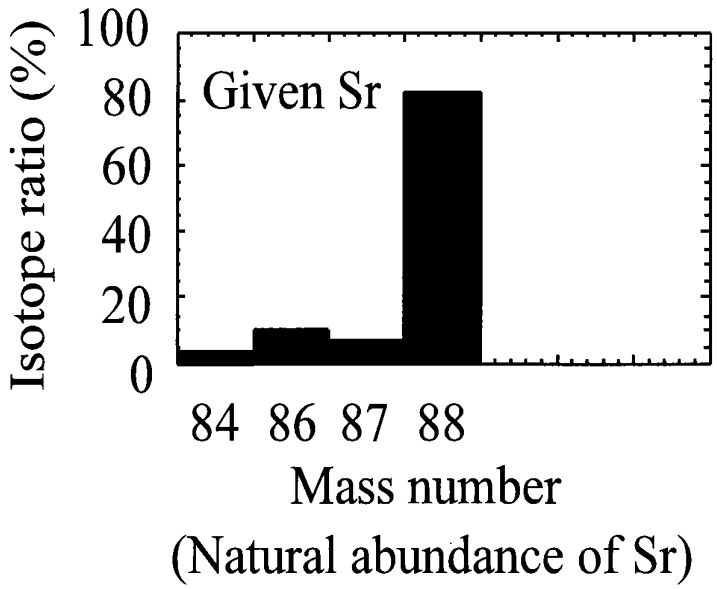
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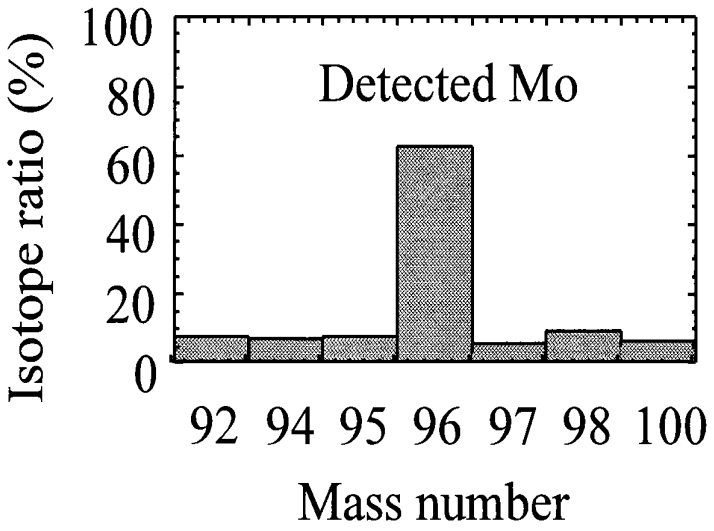




Relation of Isotopic Composition between Sr and Mo

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Mass N. +8

$^{88}_{38}Sr \rightarrow {}^{96}_{42}Mo$

Atomic N. +4

Mass N. +8

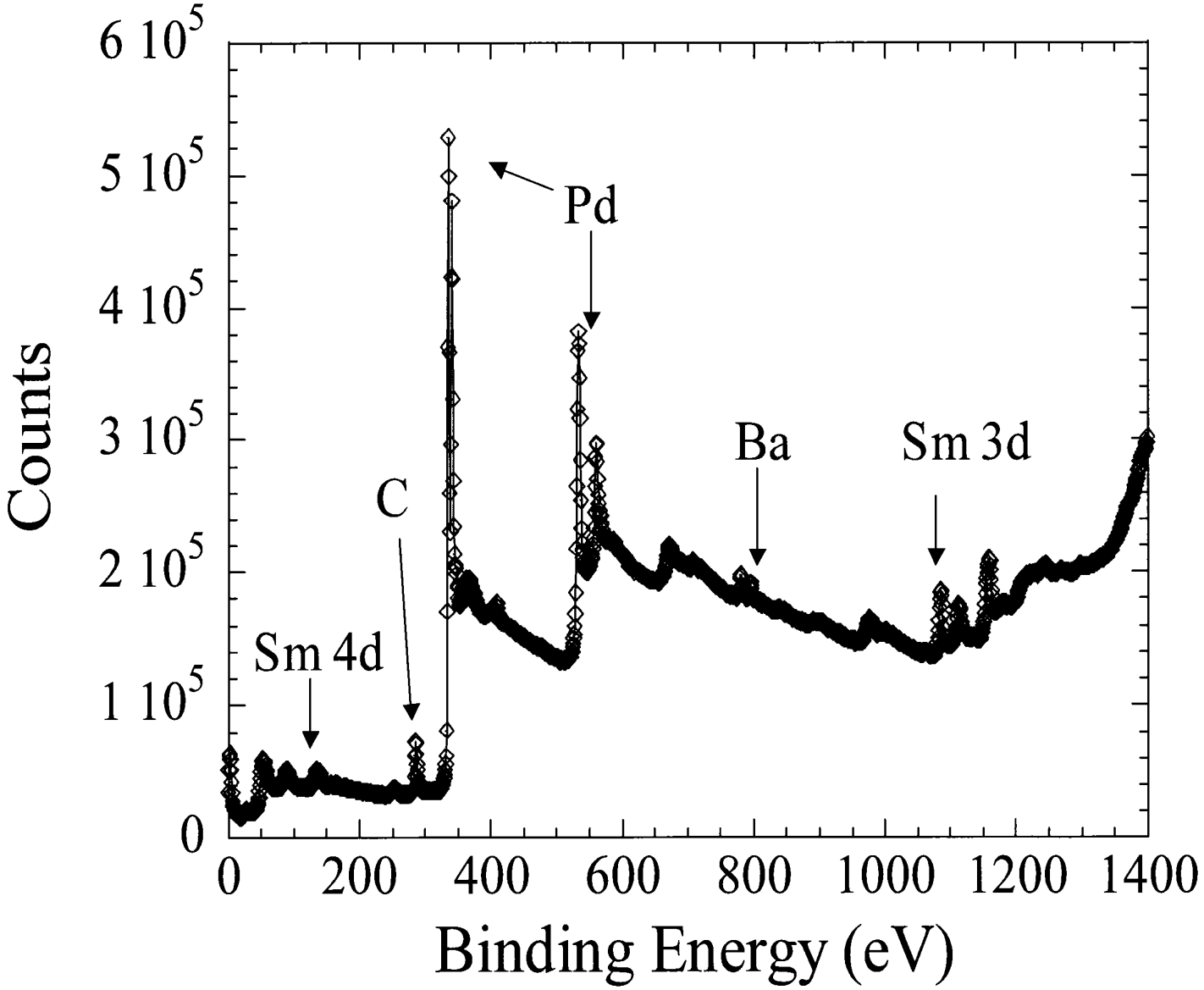
$^{133}_{55}Cs \rightarrow {}^{141}_{59}\mathrm{Pr}$

Atomic N. +4

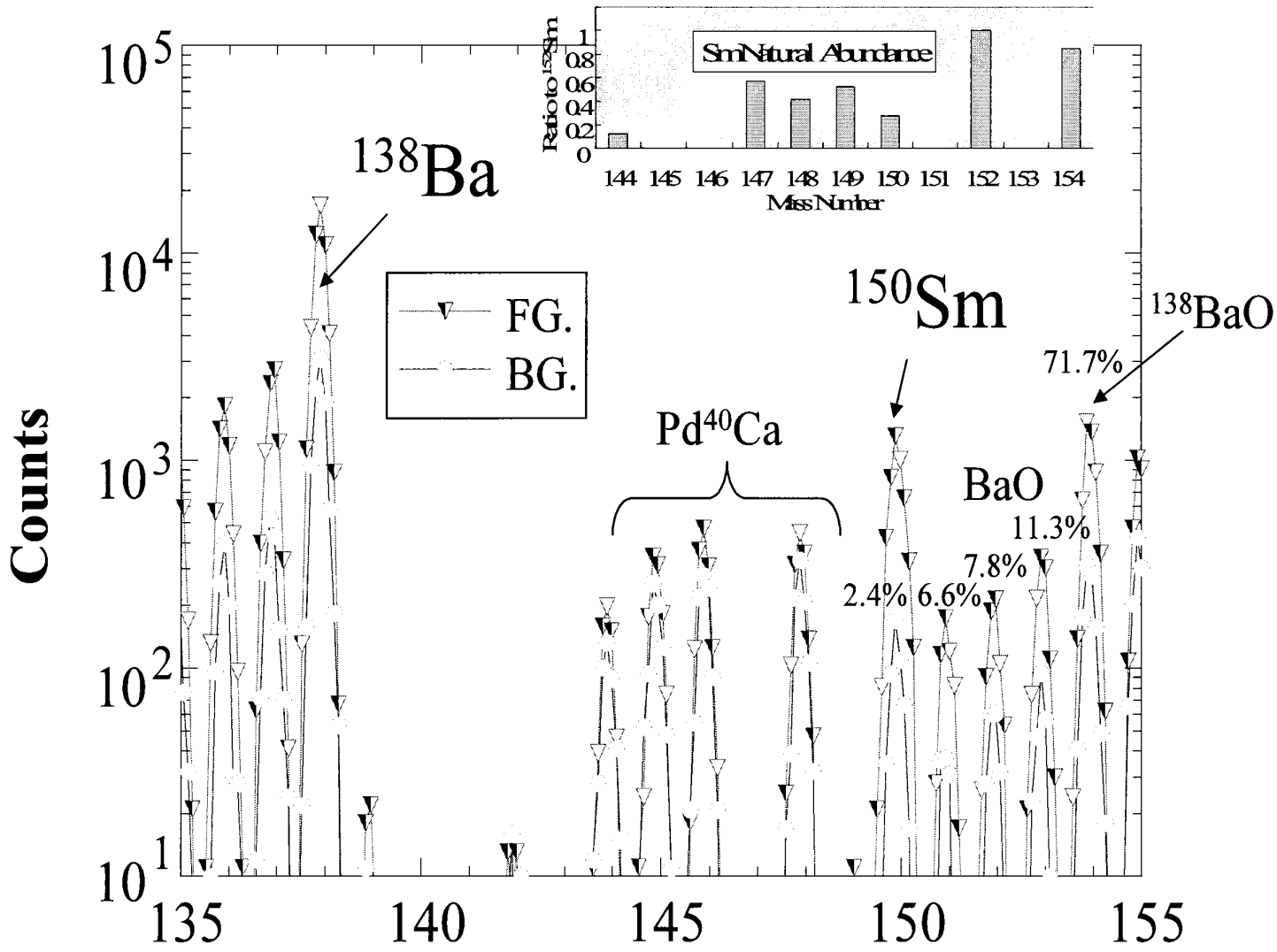
Transmutation of Ba into Sm;

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Natural Ba

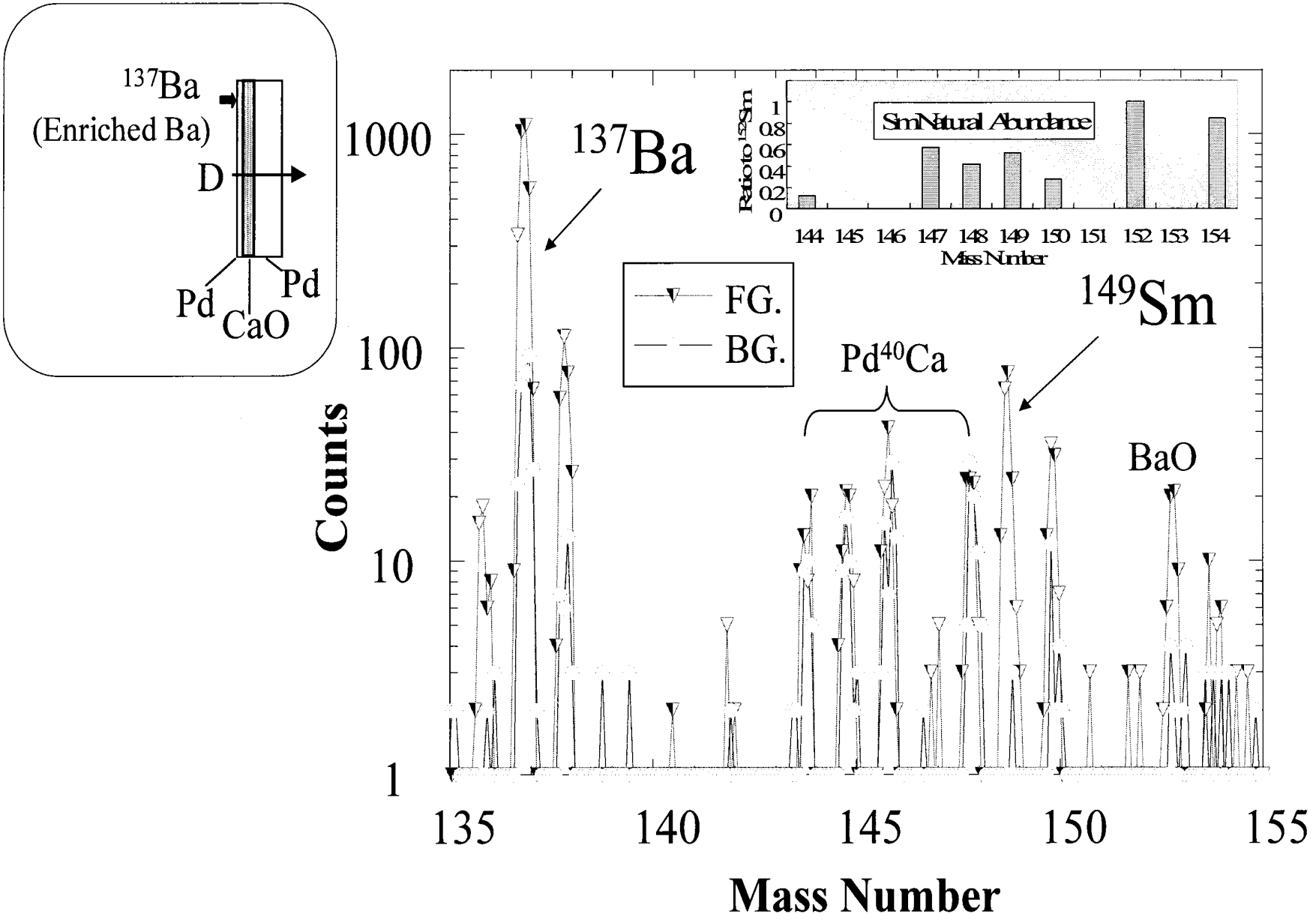


SIMS Spectra for a Natural Ba Experiment



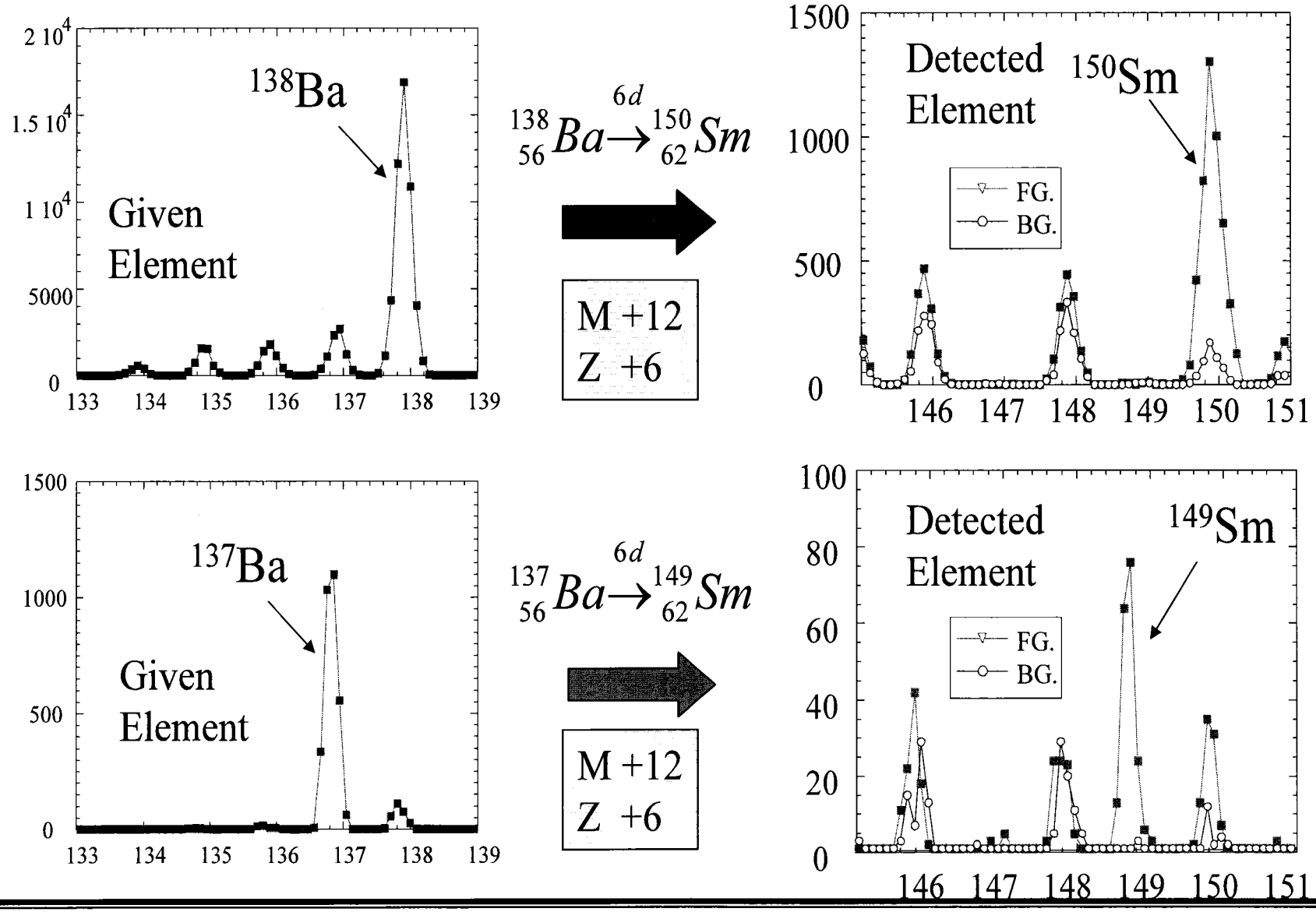
SIMS Spectra for ^{137}Ba Exp.

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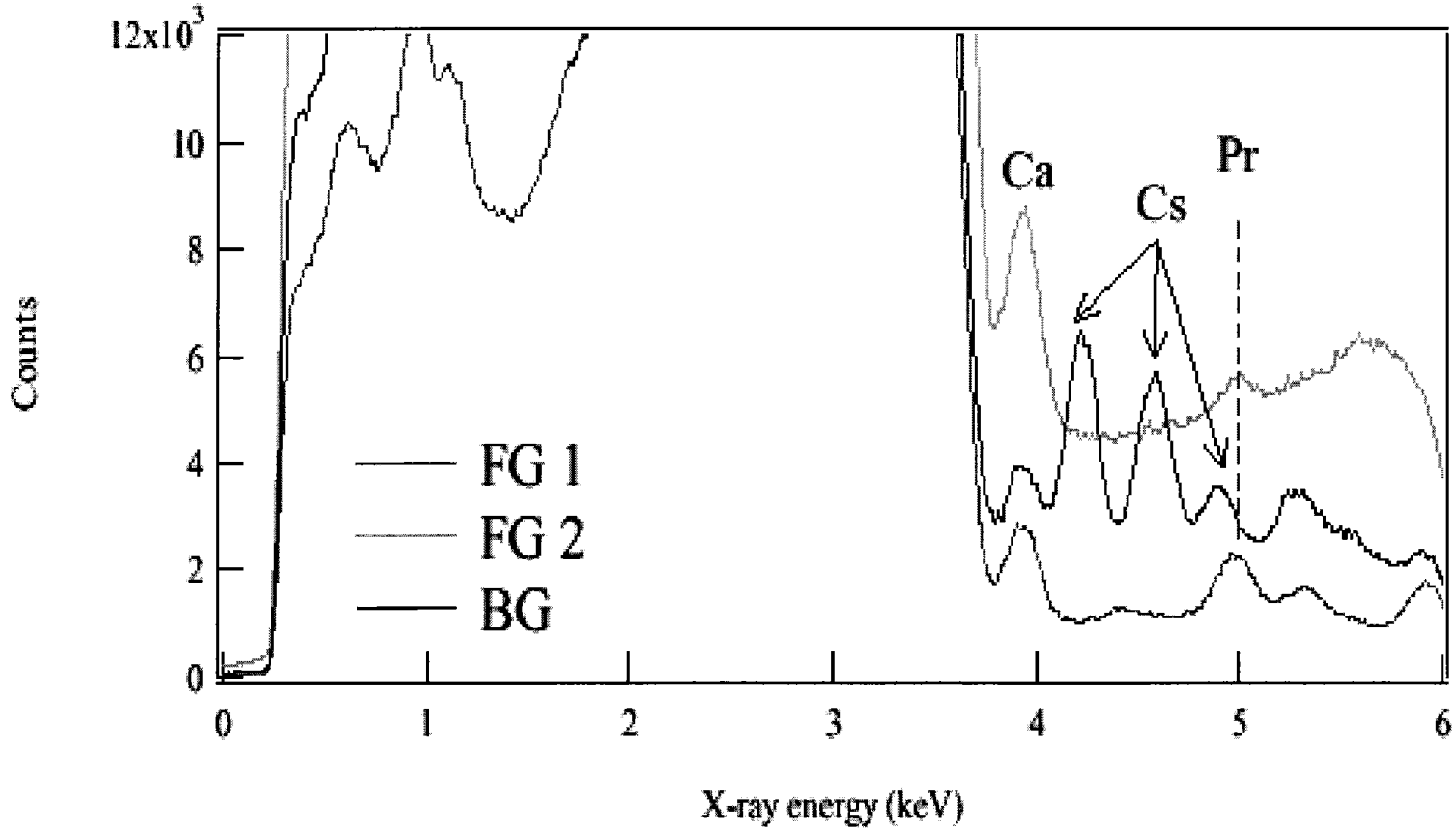
Mass Correlation between Given and Detected Elements

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Identification of Pr by XRF (2003)

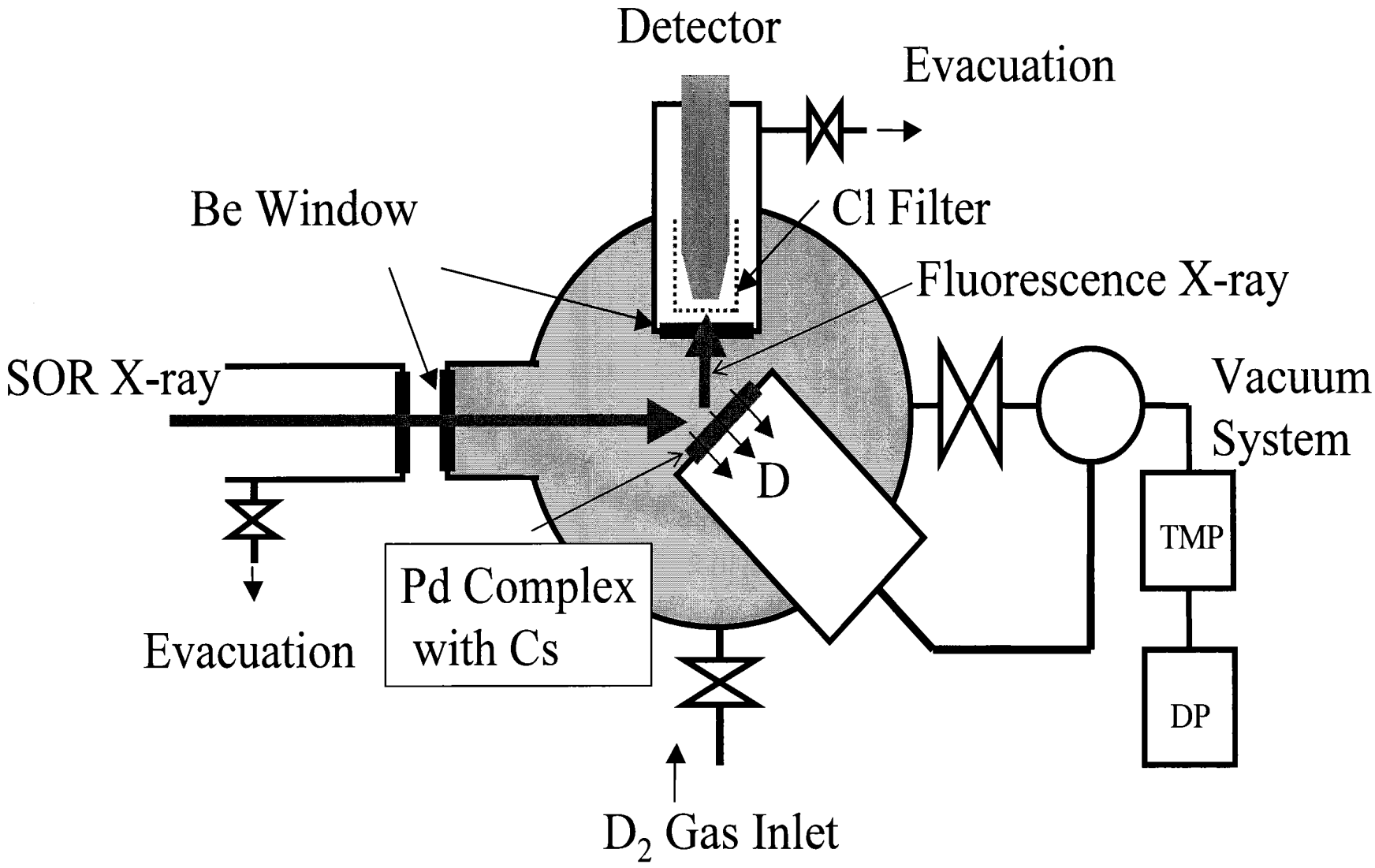
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Detection of Pr using SOR X-ray at Spring-8, Harima, Japan
(FG1,FG2:Signals from Samples after D2 Permeation
BG:Signals from the sample before Permeation)

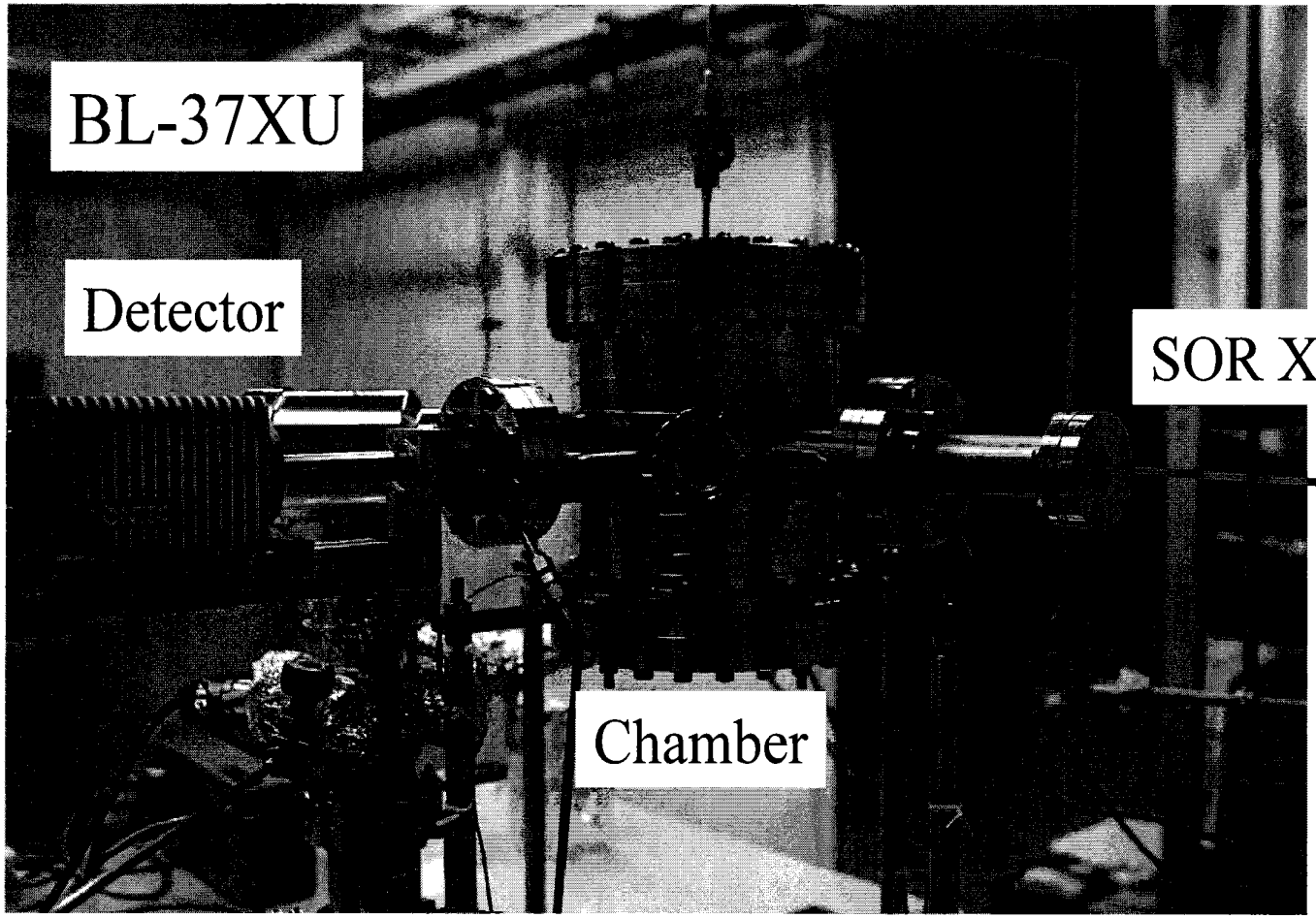
Experimental Set-up for *in-situ* Measurement located at SPring-8

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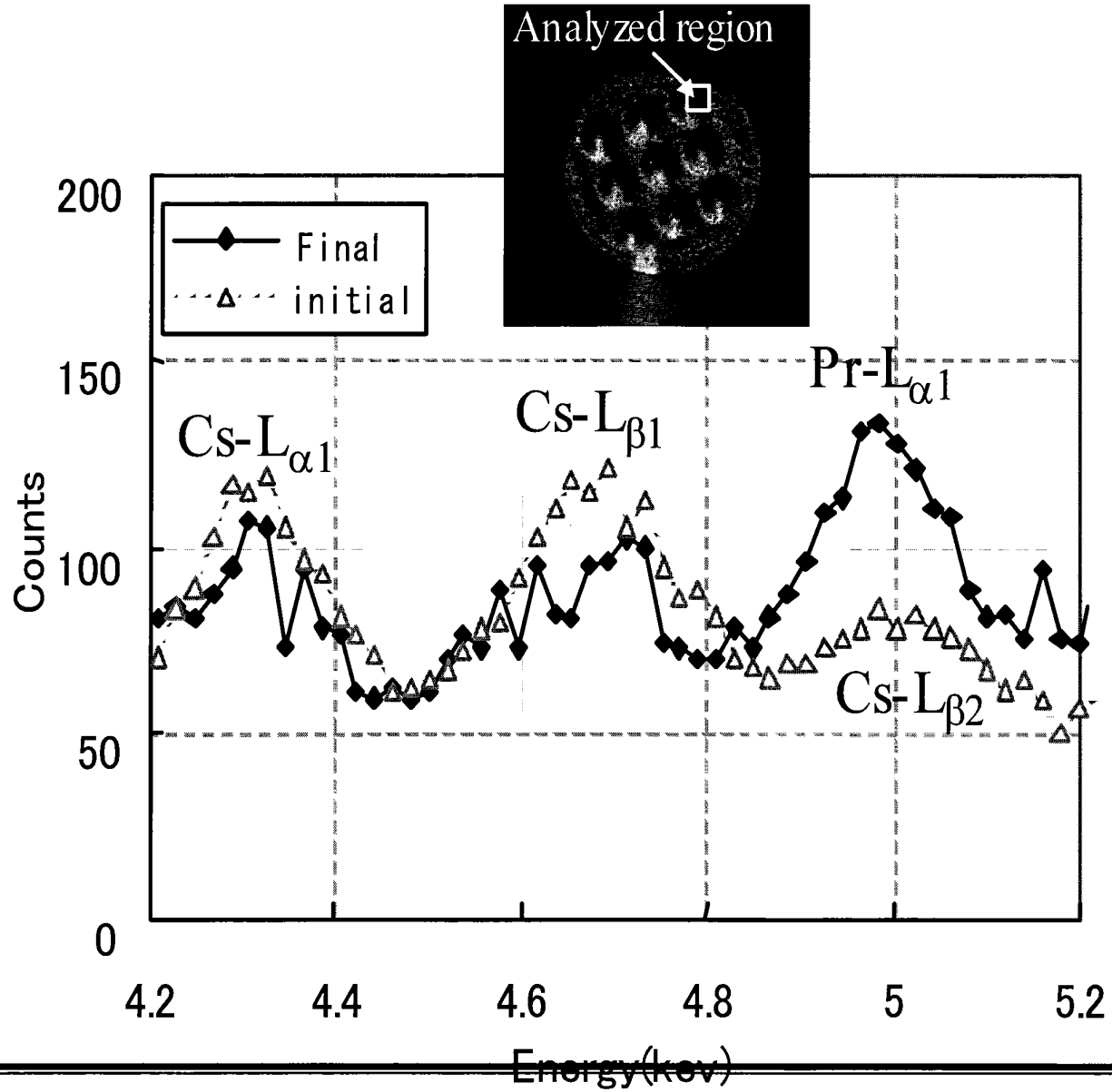
Photograph of the Experimental Set-up

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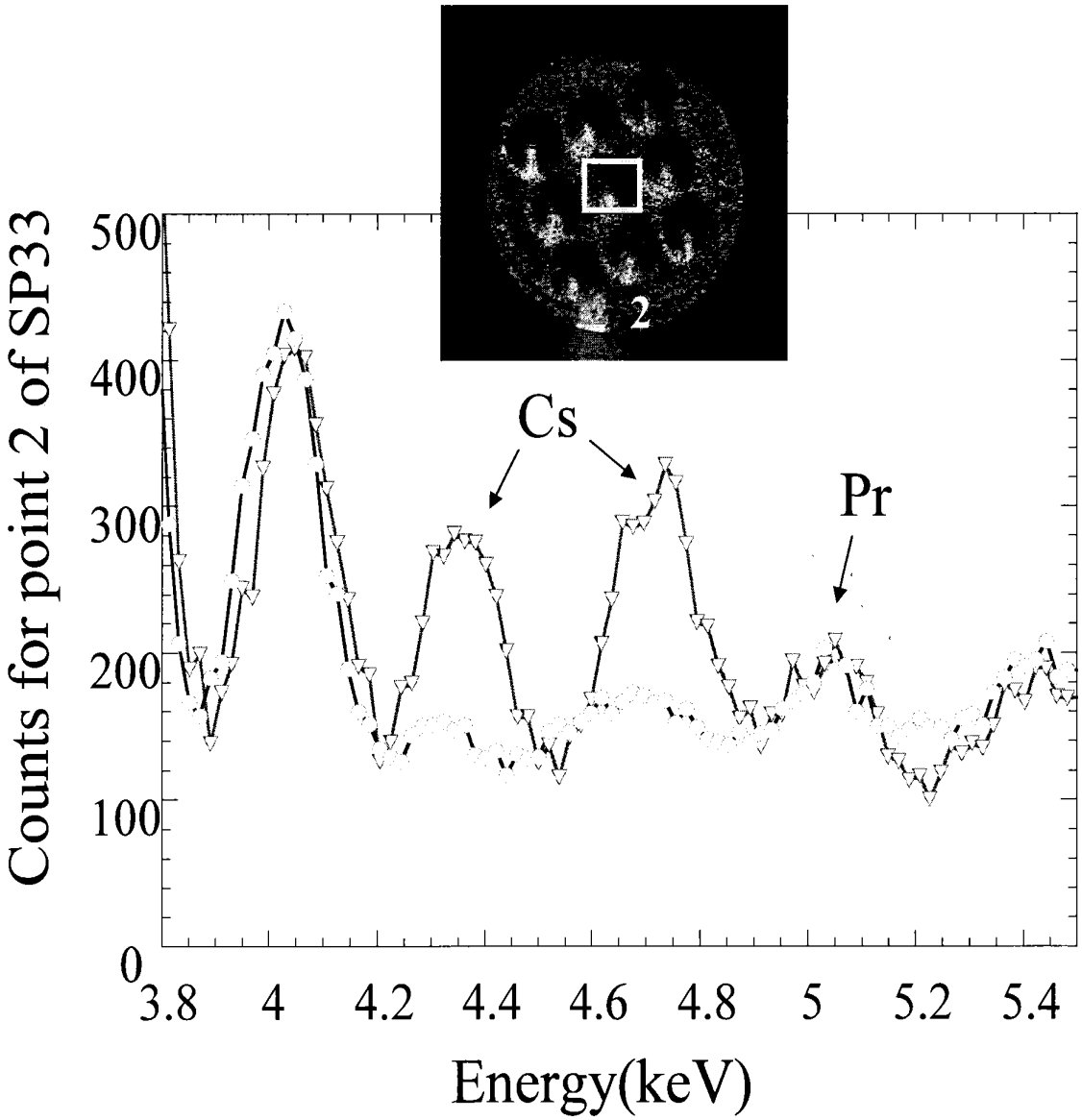
Detection of Pr; SP-24

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Detection of Pr; SP-33

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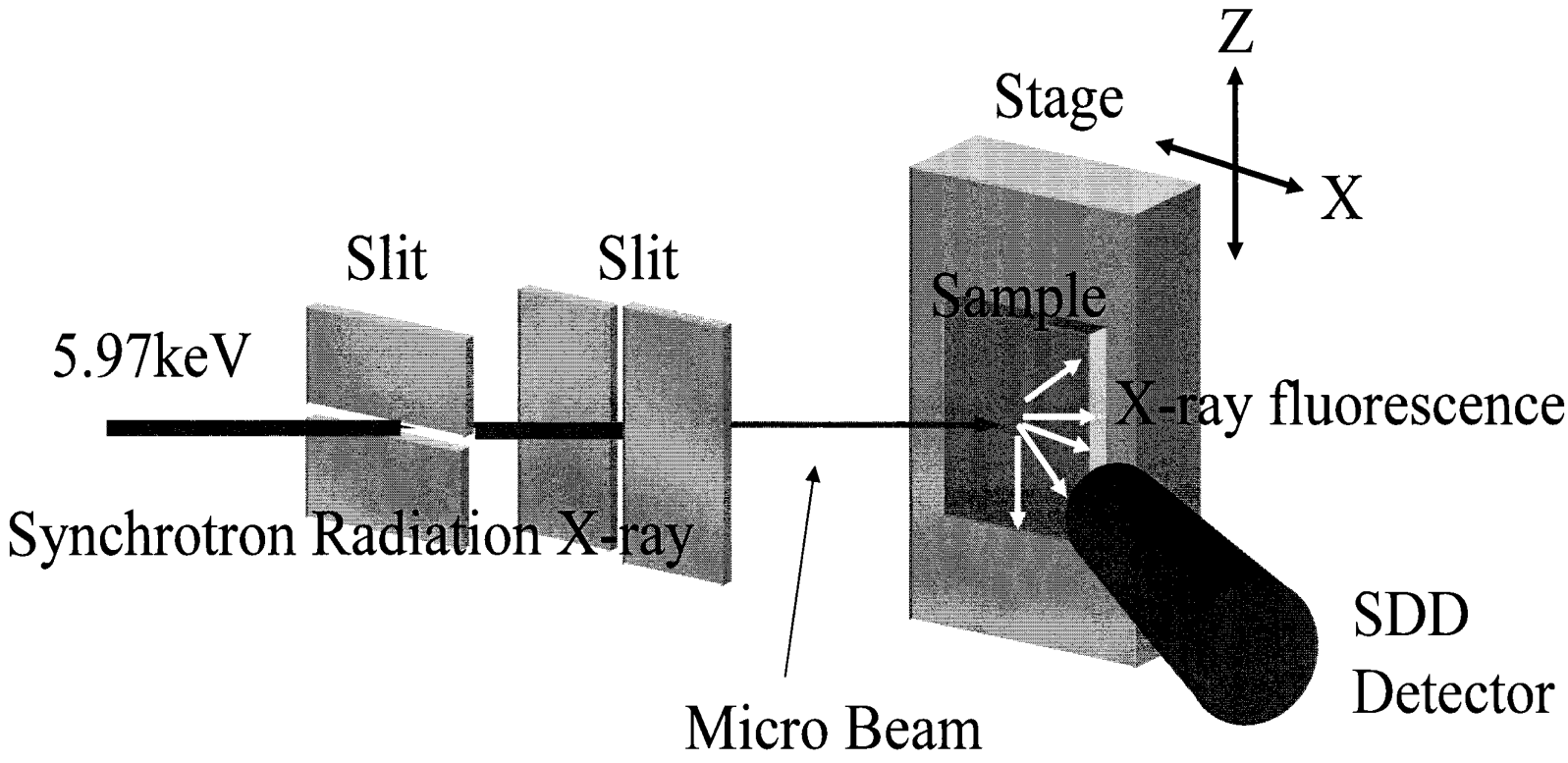


- Distribution of Pr -

12	11	10
6	5	4
3	2	1
9	8	7
15	14	13

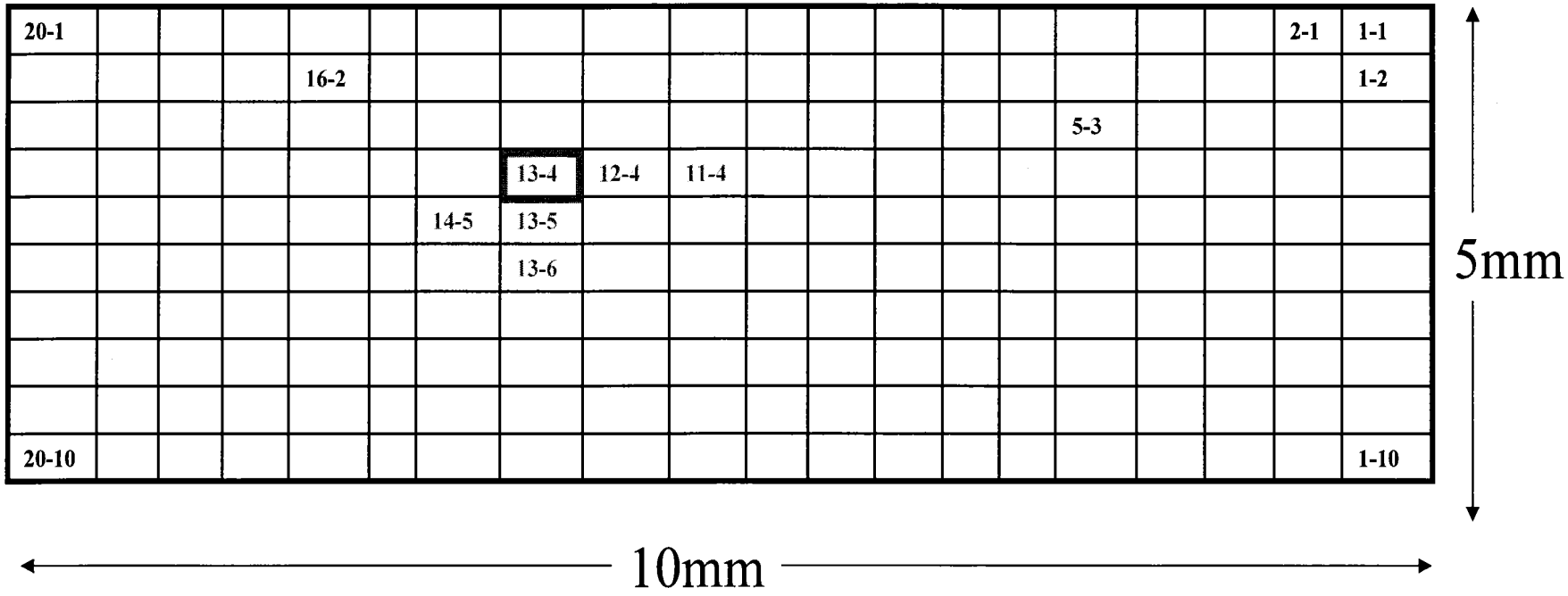
Red:Pr detected
Blue:No Pr
Black:No initial Cs

Experimental Setup for Measurement of Pr Distribution



Mapping of Products by 500 micron X-ray Beam; SP-24 (*in-situ* Exp.)

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Red : Detection of Pr only; 6points (3%)

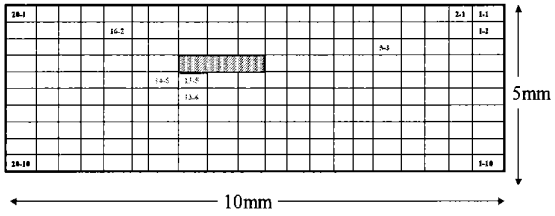
Blue : Detection of Pr and unidentified element;2points (1%)

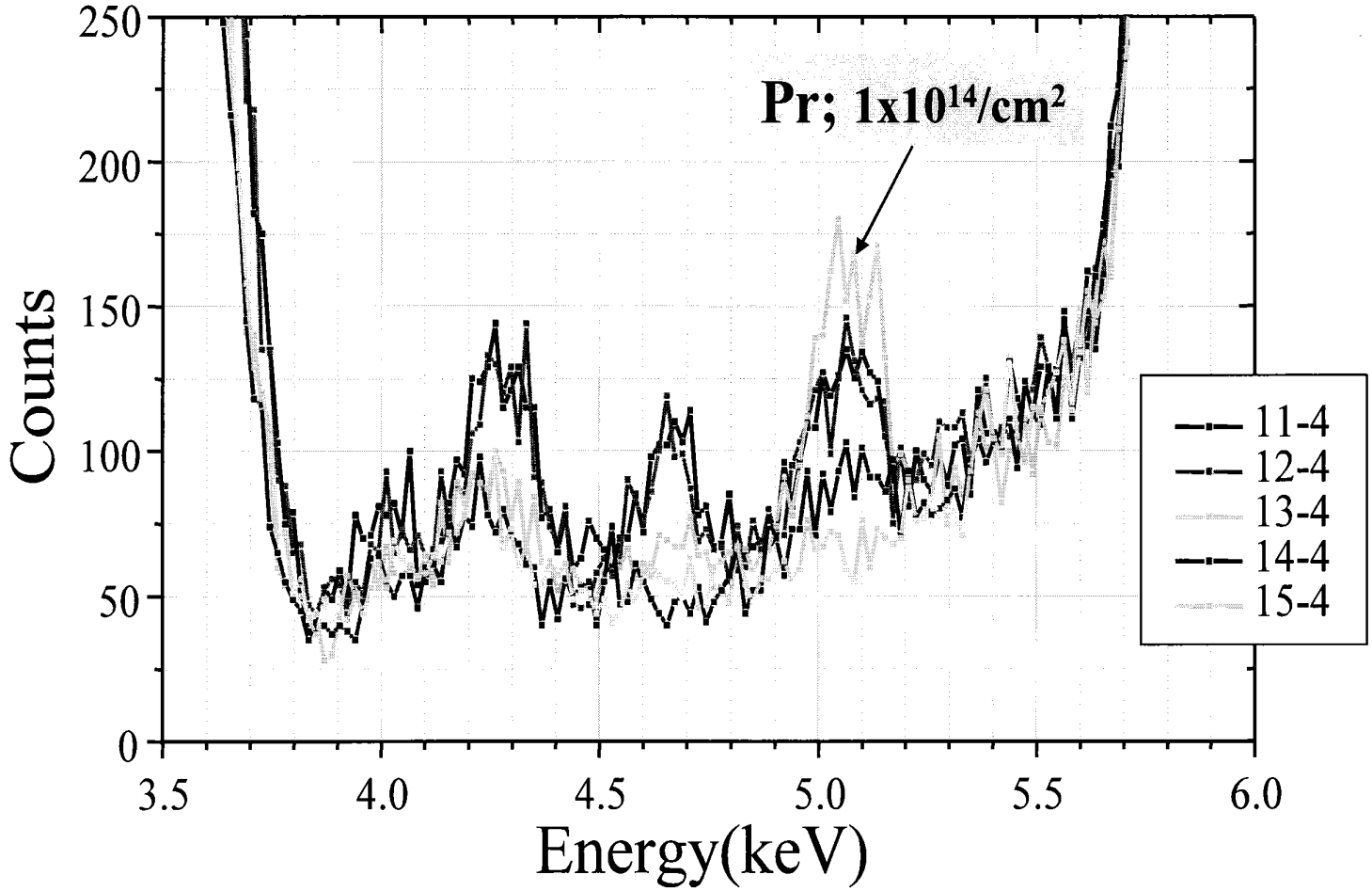
Black : No Detection;192points (96%)

Pr detection, SP-24, 500 micron beam

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Point from11-4 to 13-4

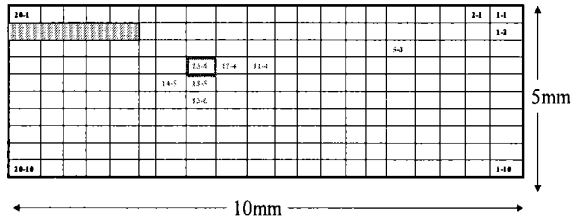


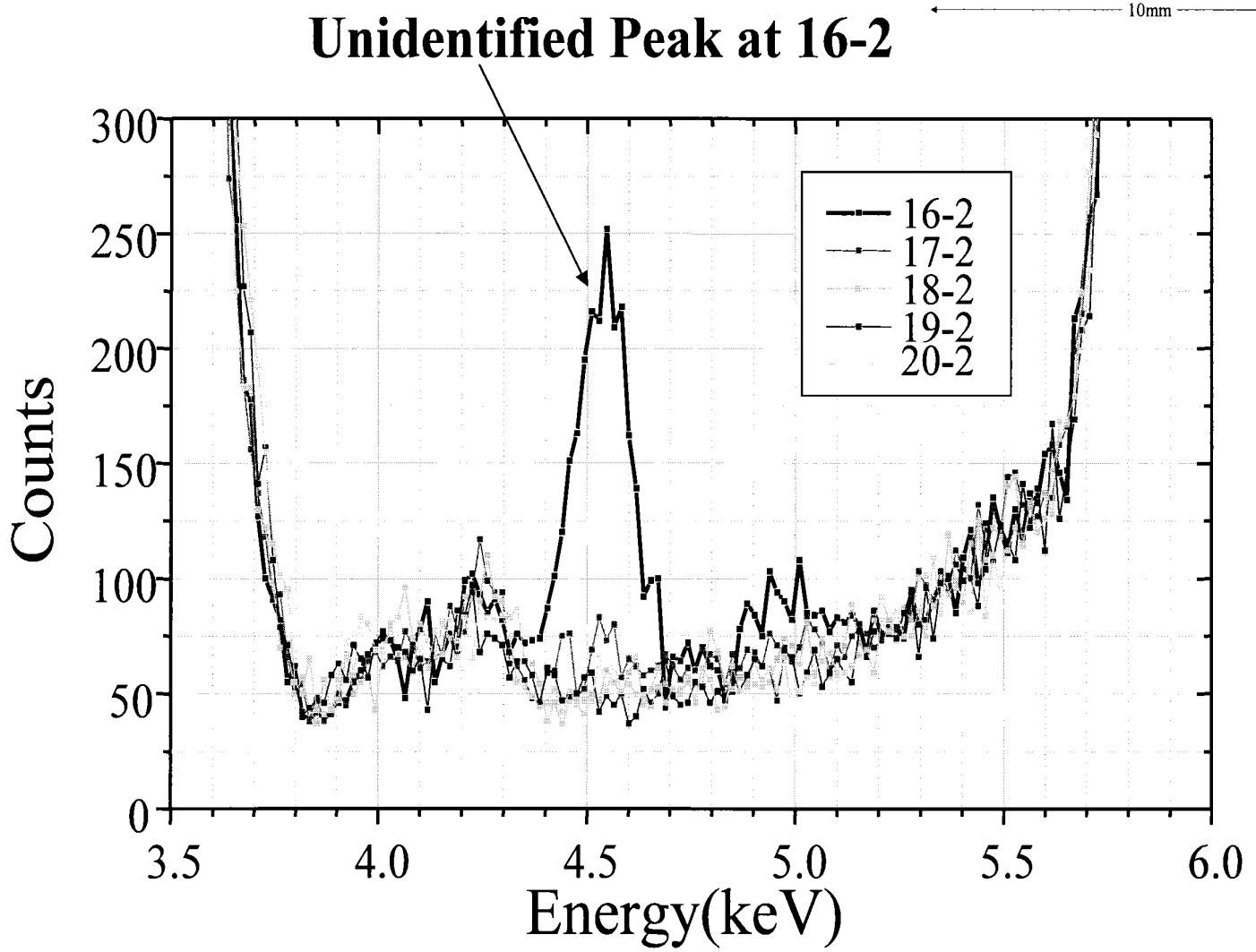


Unidentified Peak, SP-24, 500 micron beam

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Point from16-2 to 20-2

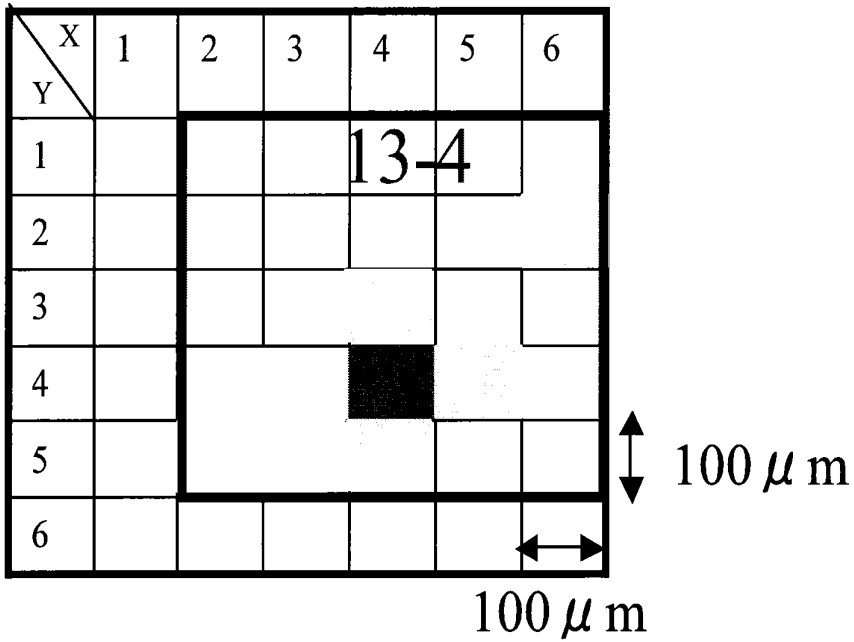


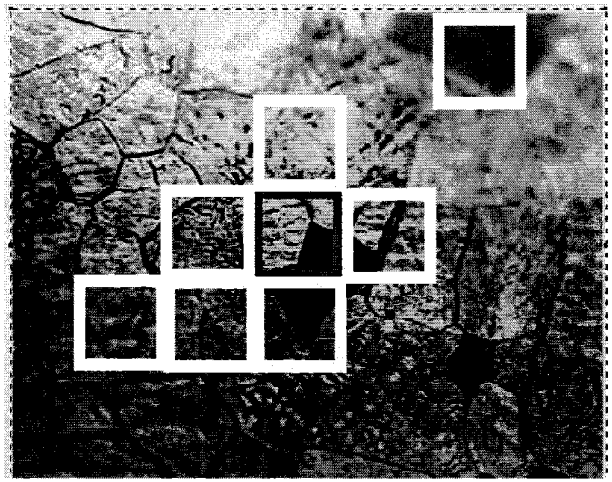


Smaller beam analysis of Pr Region

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100 micron beam;SP-24, 13-4





Much Pr detection

Pr detection

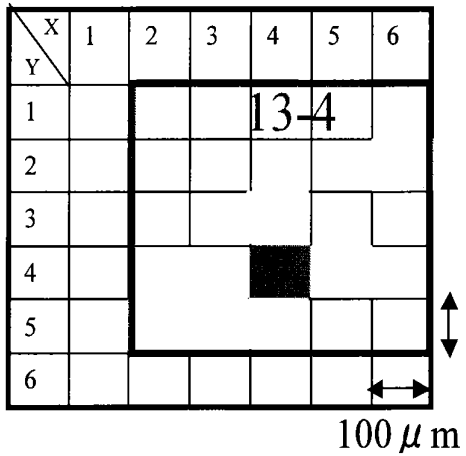
No Pr

If we use smaller size X-ray beam, we can see that Pr is localized.

Smaller beam analysis of Pr Region

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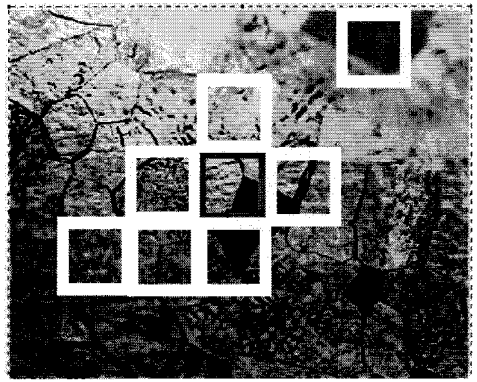
100 micron beam;SP-24, 13-4

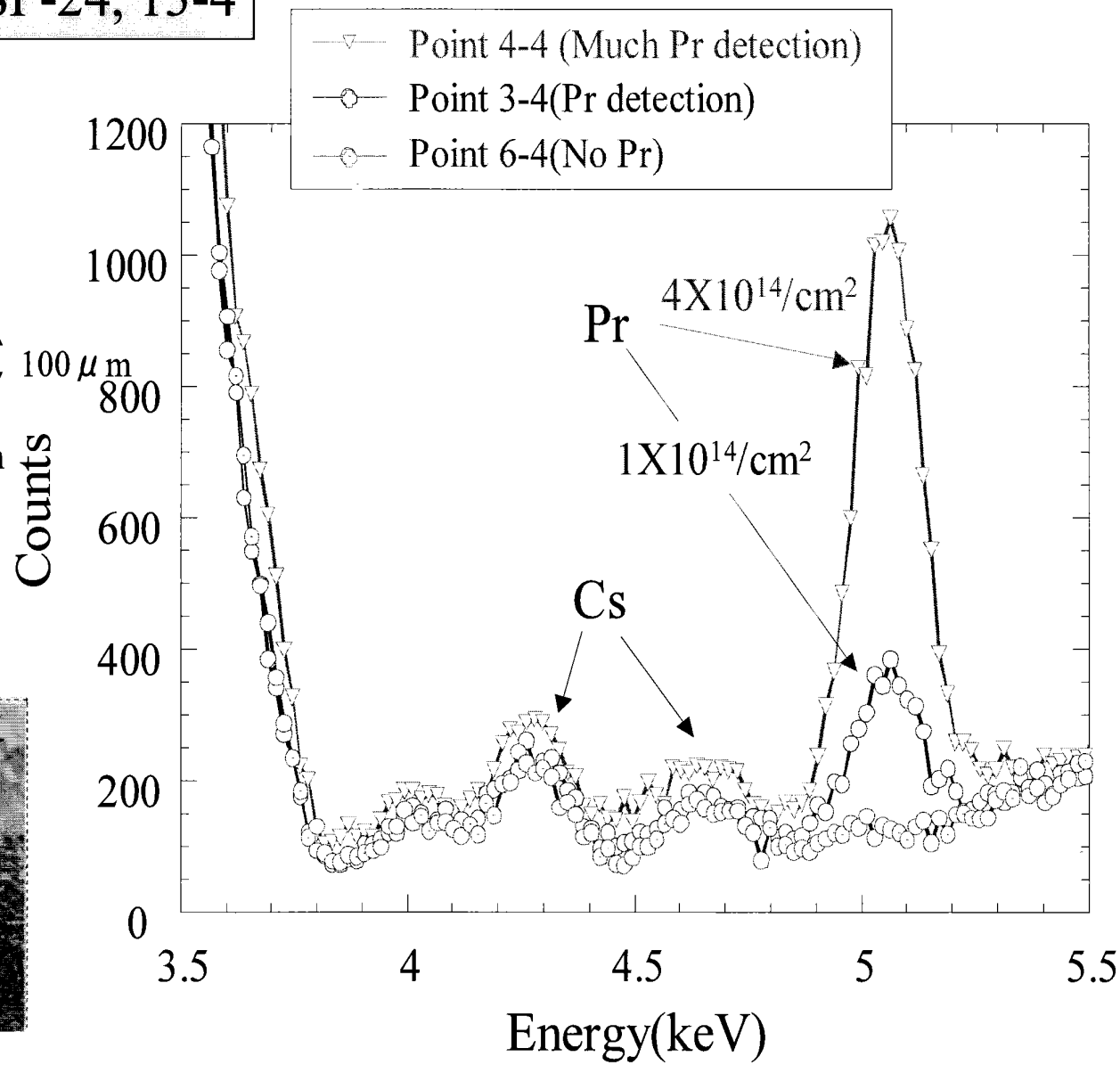


Much Pr detection

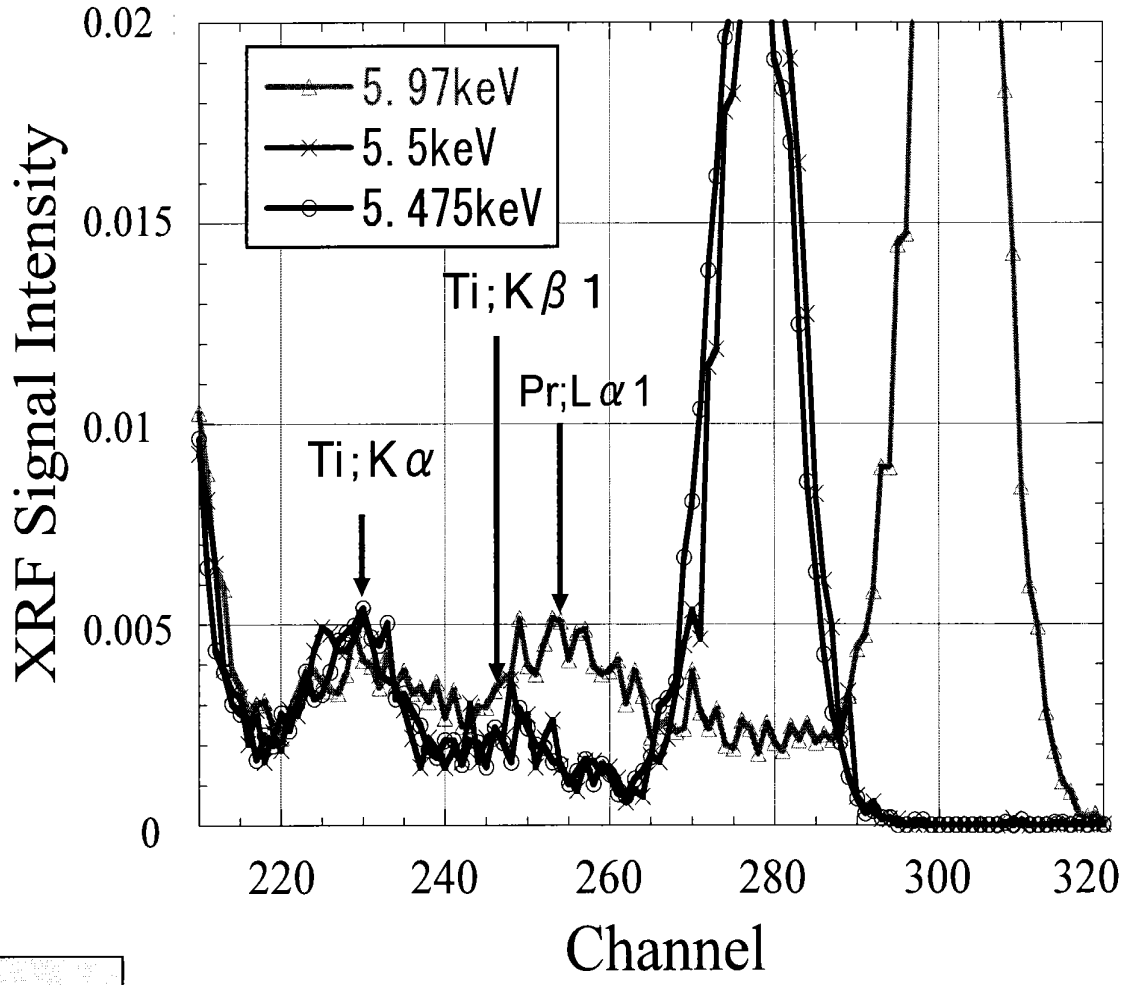
Pr detection

No Pr





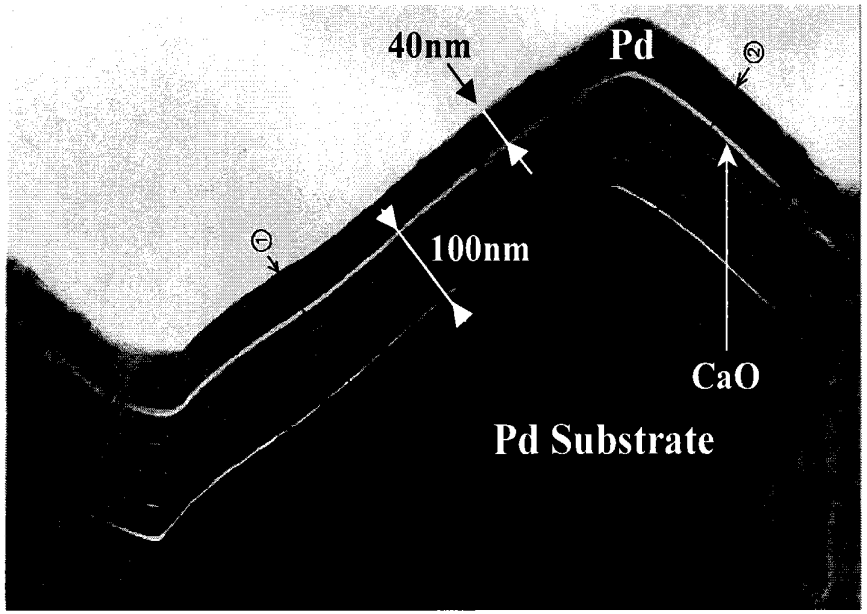
Identification of the unidentified Peak by Energy Scan XRF

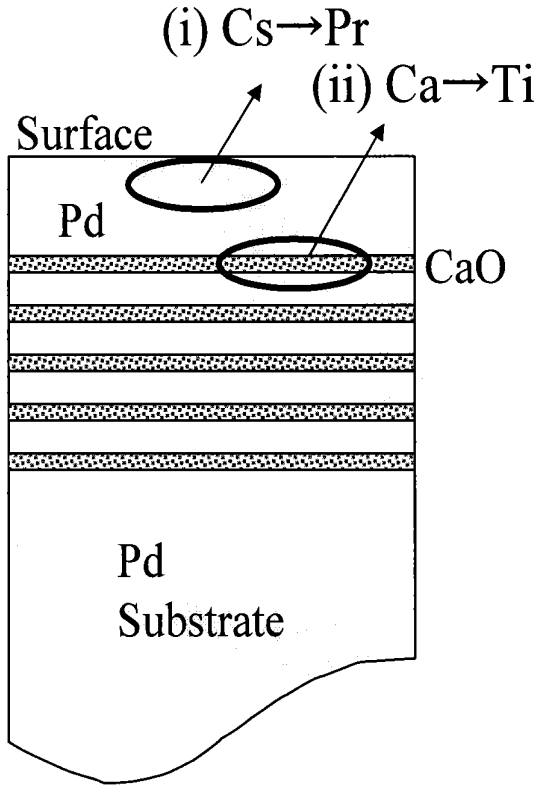


Ti detected

Possible Origin of the detected Ti

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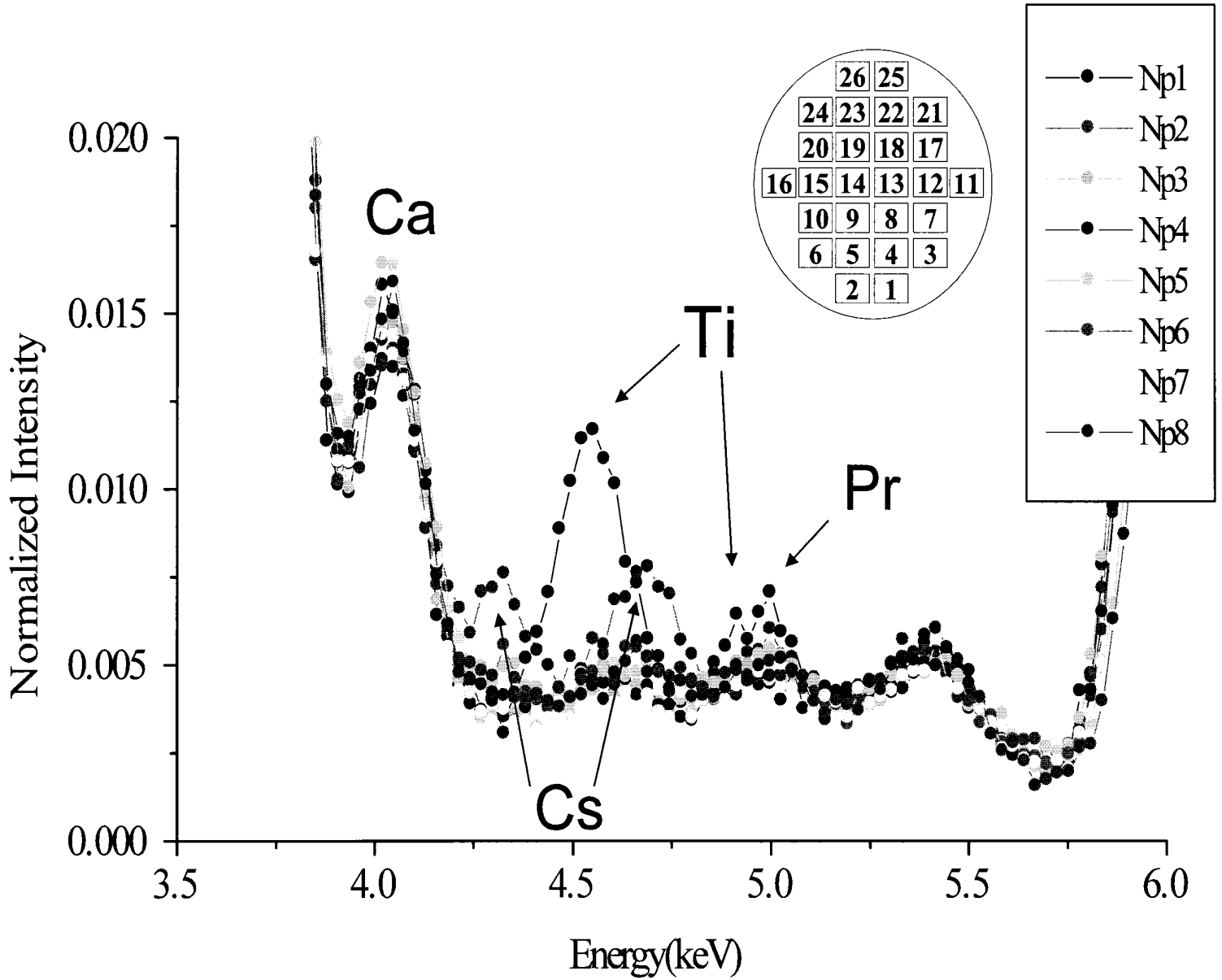


Ti could be transmuted from Ca inside

⇨ Deeper region transmutation?

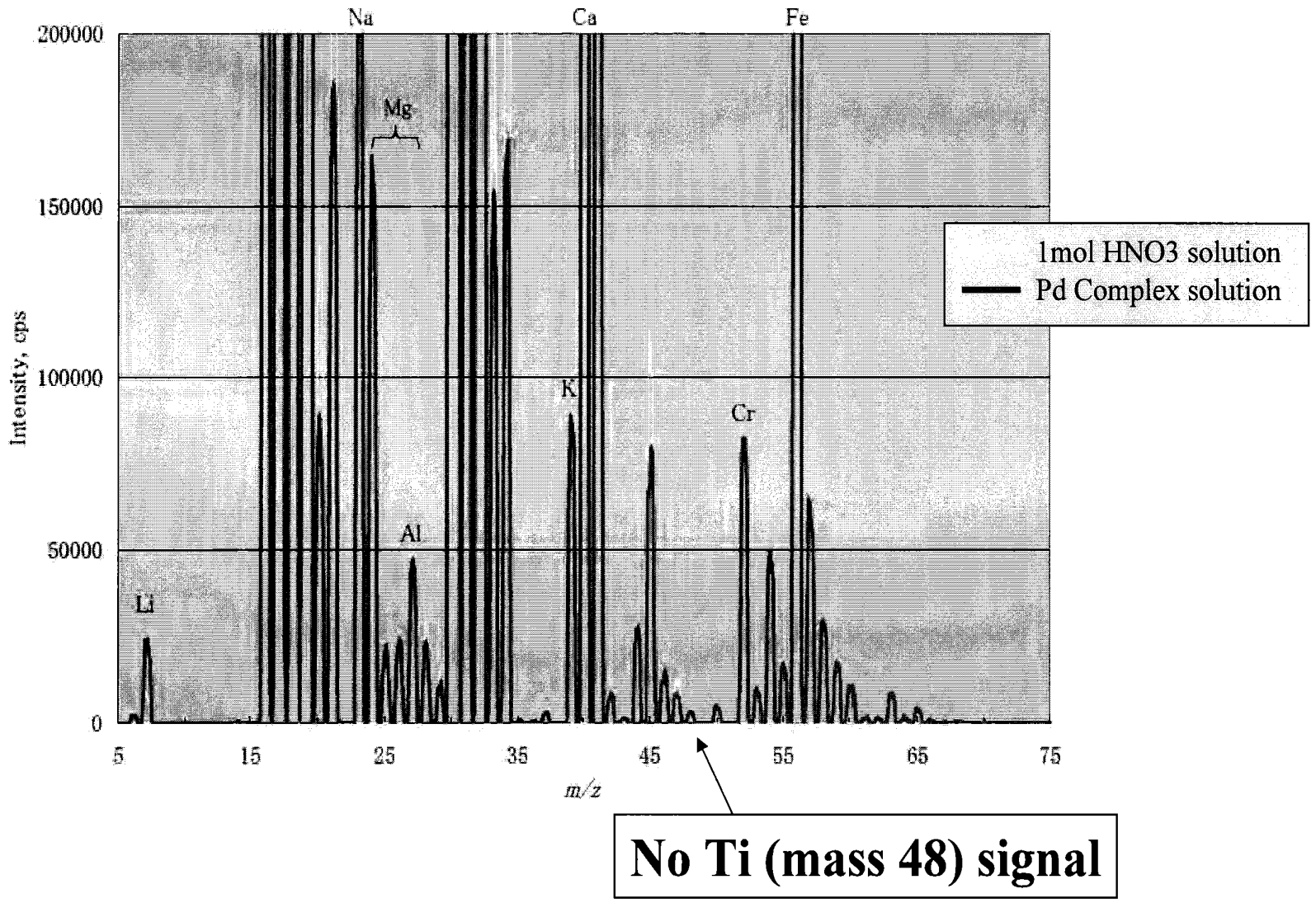
Detection of Pr and Ti by XRF

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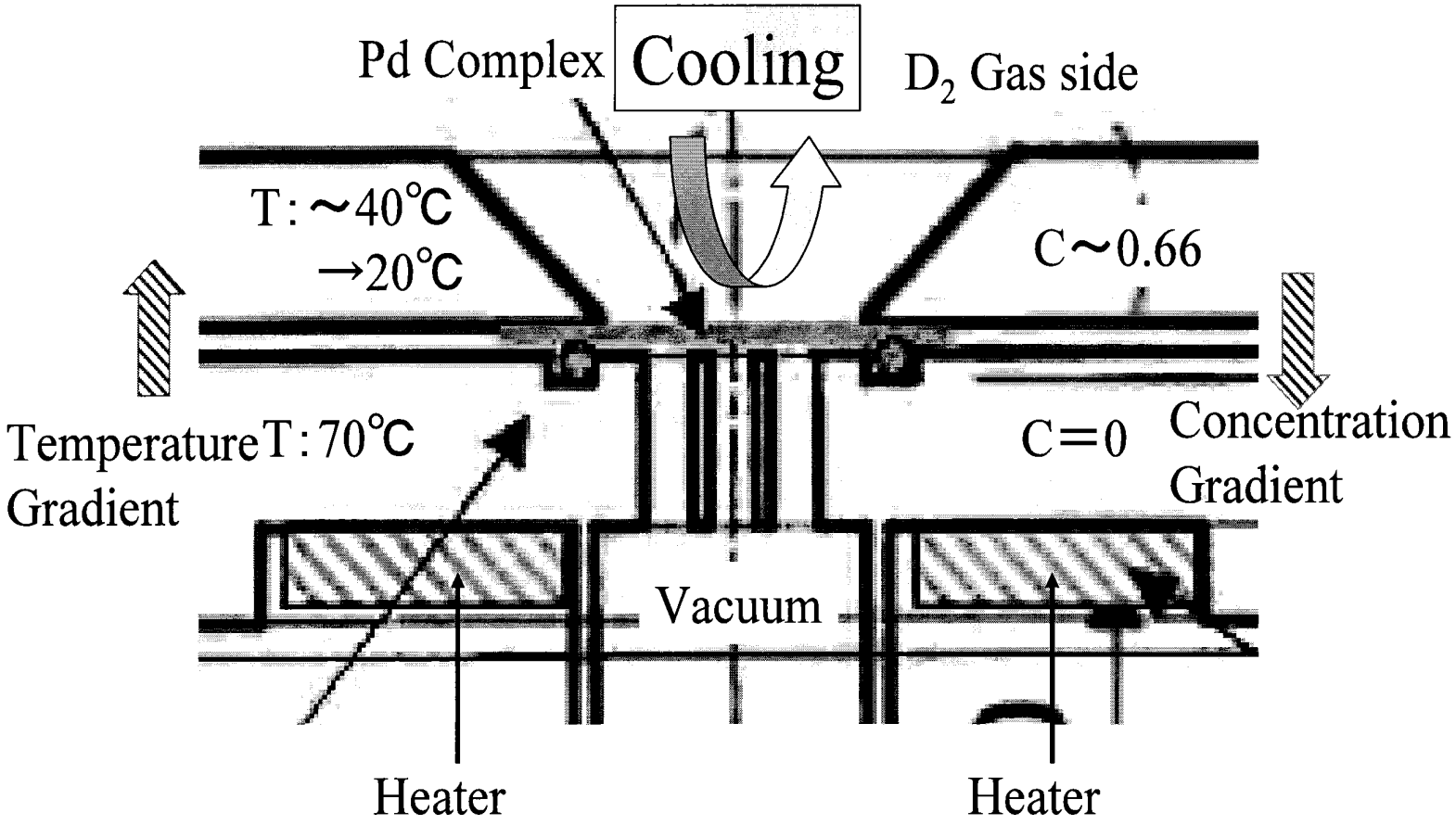
Impurity Analysis of a Pd complex before permeation by ICP-MS

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Effect on D density by gradient T

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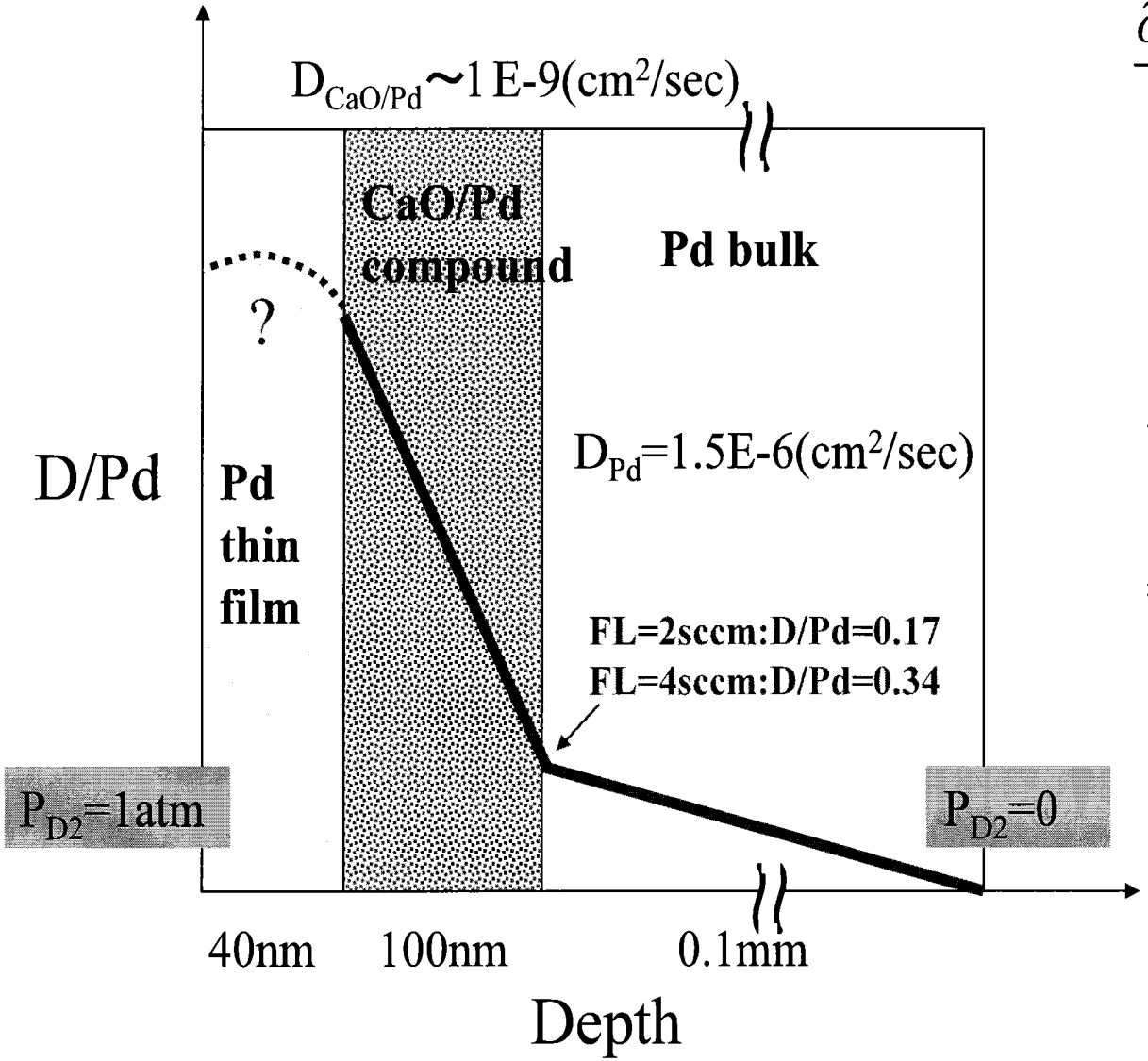
$$\mathbf{J} = \mathbf{J}_{diffusion} + \mathbf{J}_{drift} = -nD\nabla c + ncM\mathbf{F}$$

$$= -nD(\nabla c + \frac{cQ^*\nabla T}{k_B T^2}) \qquad Q^* : \text{Heat of Transport}$$

Density of D on the D2 side surface would be increased.

D distribution in the Pd Complex

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$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} \qquad \frac{\partial}{\partial t} = 0$$

$$Q = A \cdot J = -A \cdot D\frac{\partial C}{\partial x}$$

$$-A \cdot D_{CaO/Pd} \cdot \left.\frac{\partial C}{\partial x}\right|_{CaO/Pd}$$

$$= -A \cdot D_{Pd} \cdot \left.\frac{\partial C}{\partial x}\right|_{Pd}$$

$$D_{CaO/Pd} \le D_{Pd}$$

$$\left.\frac{\partial C}{\partial x}\right|_{CaO/Pd} \ge \left.\frac{\partial C}{\partial x}\right|_{Pd}$$

D distribution will be observed by using the Nuclear Resonance Reaction at Univ. of Tokyo.

Concluding Remarks

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1. **Low energy nuclear transmutations from Cs into Pr, Sr into Mo and Ba into Sm have been observed in the Pd complexes, which are composed of Pd and CaO thin film and Pd substrate, induced by D2 gas permeation through Pd multilayer complexes.**

2. **"In-situ" measurement of transmutation of Cs into Pr and surface distribution of Pr were investigated using X-ray Fluorescence Spectrometry at SPring-8. Unidentified Peaks except Pr were observed in some cases.**

3. **The unknown peak was identified as Ti by Energy Scan XRF. Ti could be supposed to be transmuted from Ca inside the Pd Complex. Transmutation reactions at deeper region might be induced.**